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Hyperfine interaction in molecular iodine between the 0_g^+, 1_u and 0_u^- states correlating with the $I(^2P_{1/2}) + I(^2P_{1/2})$ dissociation limit

M E Akopyan[1], V V Baturo[1], S S Lukashov[1], L D Mikheev[2,3], S A Poretsky[1], A M Pravilov[1] and O S Vasyutinskii[4,5]

[1] V A Fock Institute of Physics, Faculty of Physics, St. Petersburg State University, Ul'yanovskaya 1, Staryj Peterhof, 198504 St. Petersburg, Russia
[2] Photochemical Processes Laboratory, P N Lebedev Physical Institute, Leninsky prospekt 53, Moscow 119991, Russia
[3] National Research Nuclear University MEPhI (Moscow Engineering Physics Institute), Kashirskoe highway 31, 115409, Moscow, Russia
[4] Ioffe Institute, Russian Academy of Science, Politekhnicheskaya, 26, 194021, St. Petersburg, Russia
[5] St.Petersburg State Polytechnic University, Politekhnicheskaya, 29, 195251, St. Petersburg, Russia

E-mail: mikheev@sci.lebedev.ru, a.pravilov@spbu.ru and osv@pms.ioffe.ru

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Abstract

The three-step three-color laser population of the $I_2(\beta 1_g, \nu_\beta, J_\beta$ and $D0_u^+, \nu_D, J_D)$ rovibronic states via those of the $B0_u^+$ and 1_u, $0_g^+(bb)$ states, correlating with the second and third dissociation limits of the valence states, has been used for the study of mechanisms of optical transitions involved in the population of the $\beta 1_g$, ν_β, J_β rovibronic states. It has been shown that the $1_u(bb) \leftarrow B0_u^+$ transition is allowed due to hyperfine interactions of the $1_u(bb)$, ν_{1u}, J_{1u} and $0_g^+(bb)$, ν_0, J_0 rovibronic states, though energy gaps between these pairs of the states are huge, greater than $0.7\,cm^{-1}$. The $\Delta J = \pm 2$ lines observed in the $\beta 1_g - 1_u(bb)$ transition are also due to hyperfine interaction of the $1_u(bb)$, ν_{1u}, J_{1u} and $0_u^-(bb)$, ν_0, J_0 rovibronic states. It has been also shown that the $1_u(bb) \leftarrow B0_u^+$ transition cannot be attributed either to magnetic dipole or to electric quadrupole transitions. Contributions from the Stark effect in a strong laser field and from possible production of the $I_2(X)\ldots I_2(B)$ colliding pairs to mechanism of the $1_u(bb) - B0_u^+$ transition are negligible.

S Online supplementary data available from stacks.iop.org/JPB/48/025102/mmedia

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1. Introduction

Optical transitions which are forbidden in the electric dipole approximation are the subject of numerous studies (see [1–10] and references therein). In the homonuclear diatomic molecules, the $g \leftrightarrow u$ selection rule for electric dipole transitions is very strong. It precludes optical transitions between electronic states of the same parity with respect to permutation of identical nuclei [1]. However, in some cases the above selection rule can be violated, and the transitions can be observed, although with much smaller intensity. These cases are as follows:

1. The transitions are allowed in the magnetic dipole or electric quadrupole approximation [1, 4–6].
2. A strong static electric field, or intensive laser radiation which mixes the parities of molecular rovibronic states due to the Stark effect is applied (see [11–14] and references therein).
3. The selection rule $g \leftrightarrow u$ is cancelled since transitions occur in the colliding pairs or van der Waals (vdW) complexes [15–20].
4. The molecular rovibronic states have a mixed g, u symmetry due to the hyperfine interaction [7–10, 21–24].

